

Northwest Africa 482

Anorthositic impact melt breccia
1015 g



Figure 1: NWA 482 showing brown crust that is both terrestrial weathering (varnish) and fusion crust. Sample is approximately 10 cm in width.

Introduction

Northwest Africa (NWA) 482 was found in the Sahara desert, and purchased by M. Farmer in January 2001 in Morocco. It has a smooth dark fusion crust together with a dark brown layer of crust that could be desert varnish or from terrestrial weathering (Fig. 1). In hand sample, it is clearly a breccia with a fine grained light grey matrix and brighter light grey to white clasts. Cataclastic regions and impact melt veins also criss-cross the sample (Fig. 2).



Figure 2: Slab of NWA 482 illustrating its feldspathic mineralogy and also the cataclastic and impact melt vein textures. Scale cube has 1 cm edges.

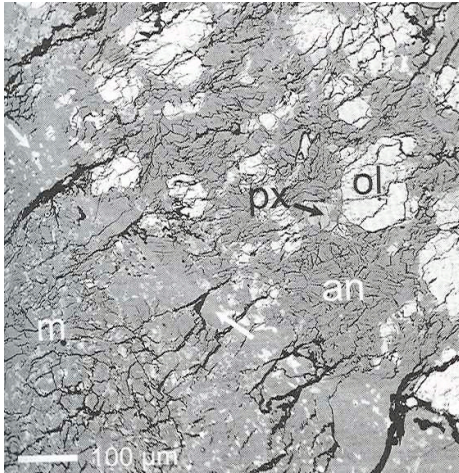


Figure 3: BSE image of a portion of NWA 482 showing a spinel troctolite clast (upper right), glassy matrix (lower left) and a thin impact melt vein at the boundary (arrow) (from Dauber et al., 2002).

Petrography and Mineralogy

There are three kinds of materials present in NWA 482 – matrix (67%), clasts (22%) and glass (11%), according to the section studied by Dauber et al. (2002). The matrix is feldspathic and is estimated to be comprised of 85% plagioclase, 5% olivine, 10% pyroxene, and minor metal and ilmenite. Clasts are ~27% mineral and ~63% lithic, that latter of which are comprised of anorthosite (some FAN-like), spinel troctolite (Fig. 3), cataclastites, with a marked absence of Mg-suite lithologies (Dauber et al., 2002; Warren et al., 2005; Korotev et al., 2003). Olivines in the mineral and lithic clasts range from Fo₆₅₋₇₇ (Fig. 4 and 5). Plagioclase is anorthite-rich, and the pyroxenes have Mg# consistent with highlands lithologies (Fig. 5 and 6). The spinels are aluminous – similar to other highlands troctolites, but much less Cr than mare basalts (Fig. 7). The glass compositions are variable, but overall anorthositic with an average FeO content of 2.82 wt% (Dauber et al., 2002). Shock levels in the meteorite are variable, but range between 30 and 75 GPa (Dauber et al., 2002).

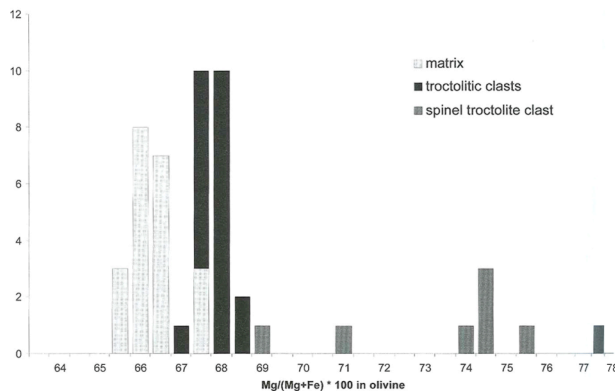


Figure 4: Histogram of olivine compositions measured in mineral and lithic clasts from NWA 482 (from Dauber et al., 2002).

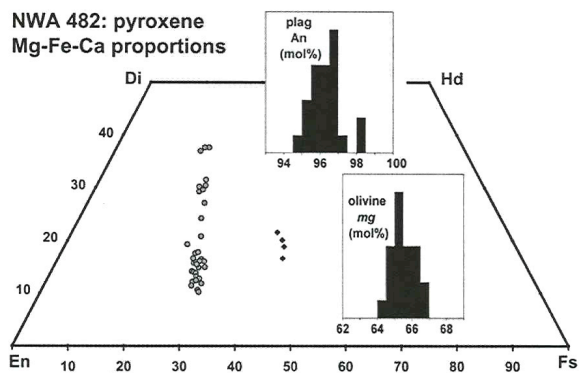


Figure 5: Pyroxene, olivine, and plagioclase compositions measured in NWA 482, showing the high Mg# of pyroxenes, the narrow compositional range of the olivine and anorthitic plagioclase (from Warren et al., 2005).

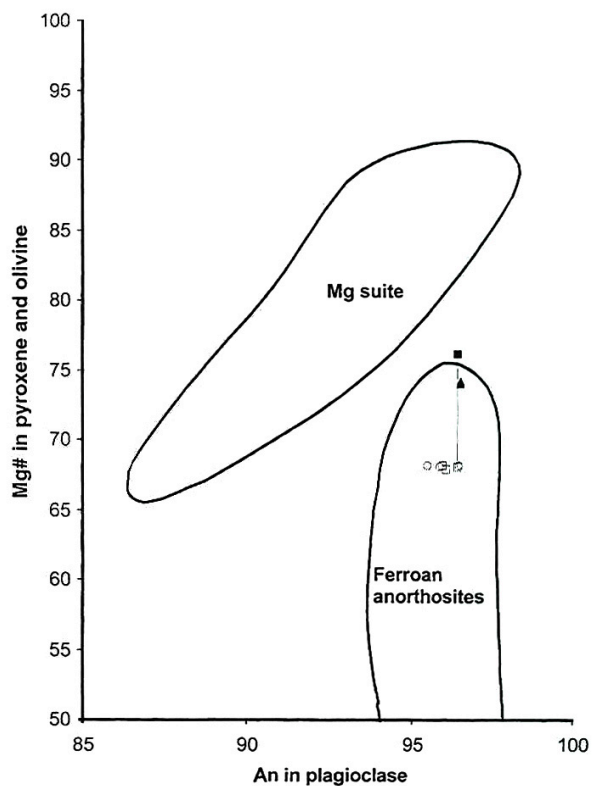


Figure 6: Compositions of coexisting pyroxenes and plagioclase in NWA 482 clasts demonstrating the absence of Apollo-like Mg-suite compositions (from Dauber et al., 2002).

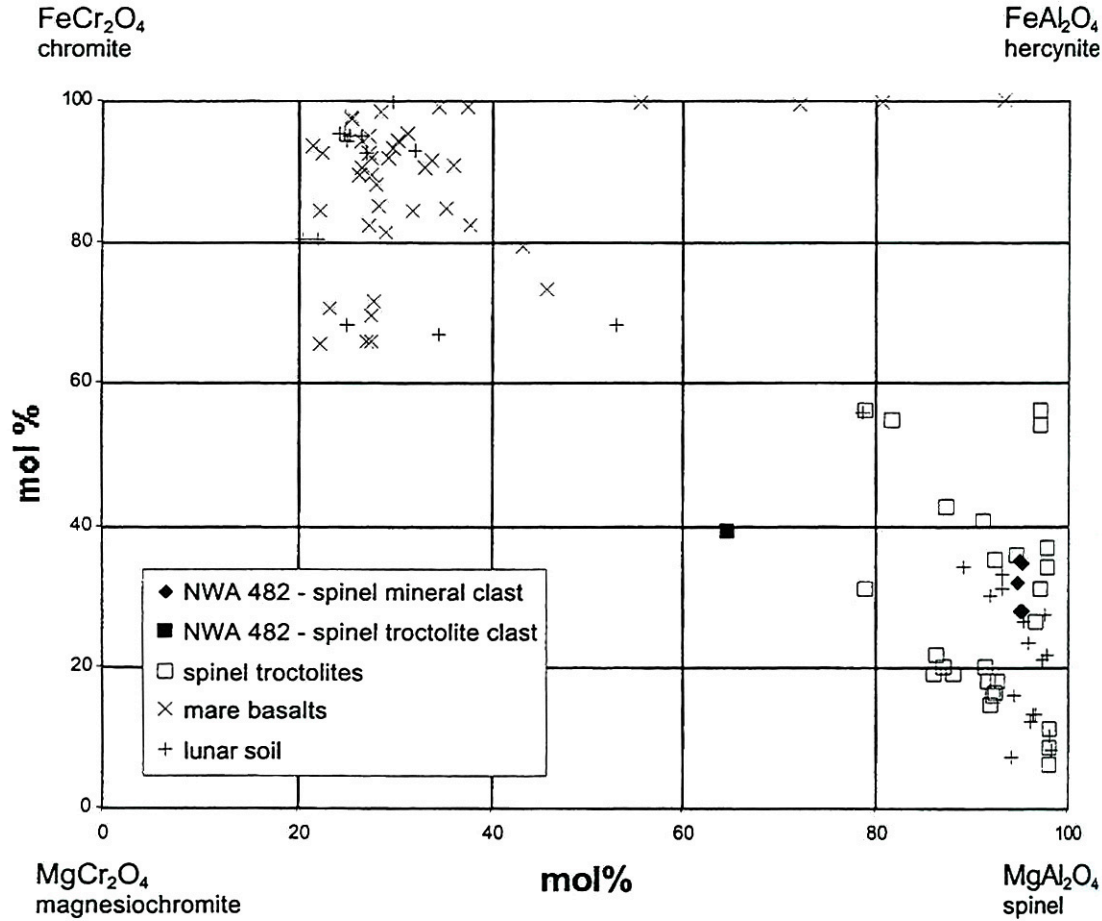


Figure 7: Spinel compositions measured in NWA 482 clasts illustrating the Al-rich nature compared to more Cr-rich spinels in mare basalts (from Dauber et al., 2002).

Chemistry

The composition of NWA 482 is among the most feldspathic of the lunar meteorites (Table 1). Its low FeO and high Al₂O₃ nearly define the end of the range (Korotev et al., 2003; Korotev, 2005). Compositionally it is very similar to the MAC 88104 and 88105 lunar feldspathic meteorites, but it has a distinctly different exposure age which precludes a launch pairing. Any KREEP component is low, given the very low REE contents of the sample (Fig. 8; Dauber et al., 2002; Warren et al., 2005; Korotev et al., 2003). Additionally, the high shock levels of NWA 482 have apparently not caused re-equilibration of movement of REE in the various clasts (Fig. 9; Consolmagno et al., 2005).

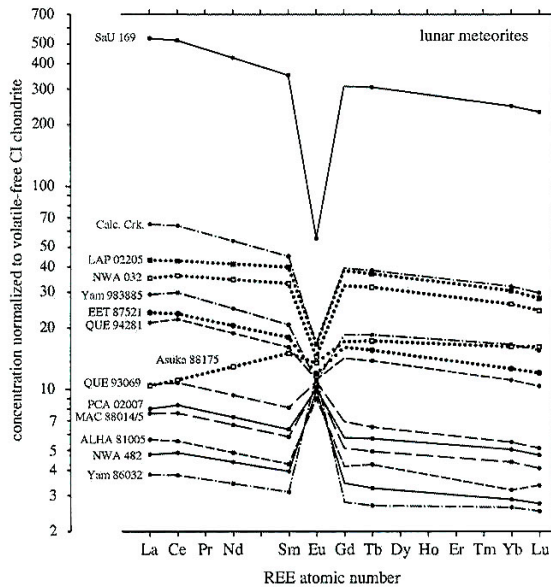


Figure 8: Rare earth element (REE) diagram for many lunar meteorites showing the REE-poor NWA 482 compared to many other feldspathic lunar meteorites (from Korotev, 2005).

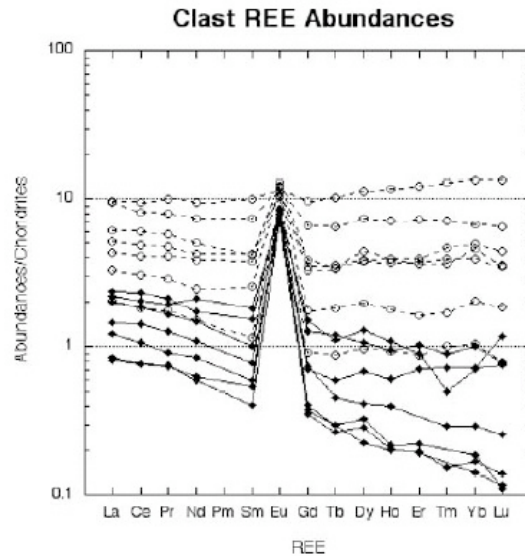


Figure 9: Rare earth element (REE) diagram for several clasts from NWA 482 (dashed and open symbols; from Consolmagno et al., 2005) showing a range of contents that were apparently not affected by high shock levels.

Radiometric ages

^{39}Ar - ^{40}Ar measurements of bulk and glass from NWA 482 (from Dauber et al., 2002), yield a diverse spectrum of ages, but the high temperature steps (1300 to 1450 °C) produce ages that have an average of 3740 to 3750 Ma (Fig. 10; bulk and glass). Lower temperature steps yielded younger ages that are high K/Ca material that could be terrestrial contamination. The 3750 Ma ages represent most likely lithification or shock ages rather than crystallization age, and is similar to the range documented for the Orientale basin. There is also evidence for a younger event at ~ 2400 Ma (Dauber et al., 2002). The combination of KREEP-poor and young ages suggests a far side origin for NWA 482 (Dauber et al., 2002).

Cosmogenic exposure ages

NWA 482 has the oldest measured lunar regolith ages for a lunar meteorite at 2070 Ma (Lorenzetti et al., 2005). A transit age has been measured by ^{10}Be at 0.9 Ma (Nishiizumi et al., 2001). A ^{36}Cl terrestrial age of 0.06 to 0.12 Ma (Nishiizumi et al., 2001) has been revised downwards to 0.015 Ma (Dauber et al., 2002). And finally, an ejection age of 0.28 Ma was proposed by Nishiizumi et al. (2001).

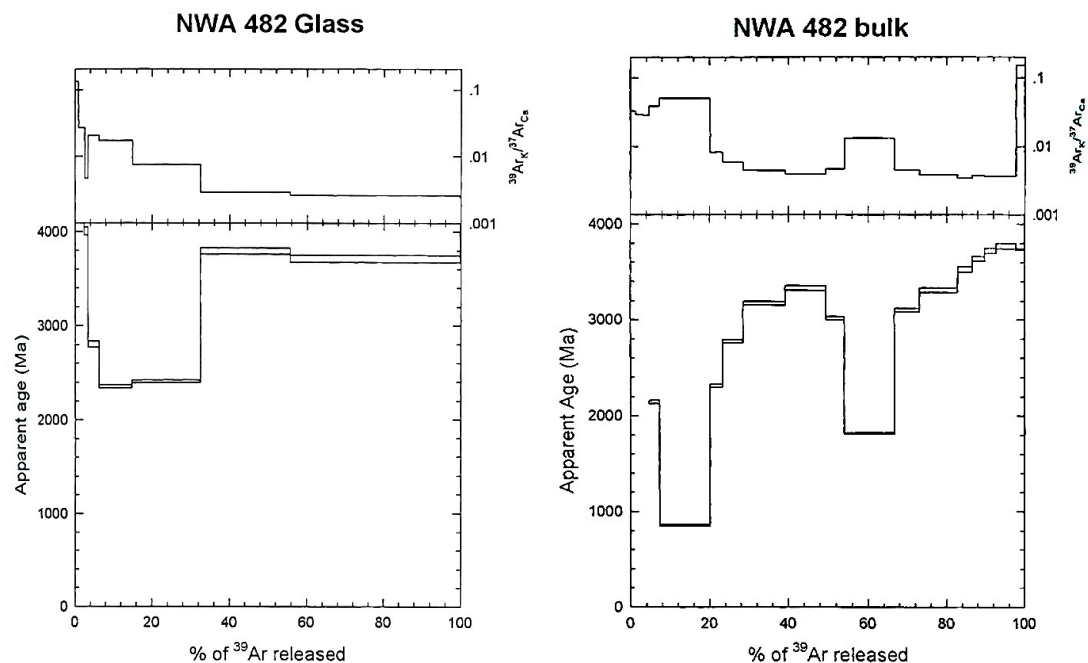


Figure 10: ^{39}Ar - ^{40}Ar measurements of bulk and glass from NWA 482 (from Dauber et al., 2002).

Table 1: Chemical composition of NWA 482

reference	1	2	2	3
weight	186	334.5		
method	e	e	g	g
SiO ₂ %	44.92		43.90	43.7
TiO ₂	0.183		0.160	0.13
Al ₂ O ₃	28.050		29.400	31.4
FeO	3.898	3.760	3.800	2.82
MnO	0.051		0.050	0.04
MgO	4.130		4.280	3.15
CaO	16.650	17.100	18.470	17.6
Na ₂ O	0.380	0.377	0.260	0.41
K ₂ O	0.036	0.040	0.035	0.02
P ₂ O ₅			0.040	0.04
S %				
sum	98.3016		100.395	99.31
Sc ppm	7.1	6.93		
V	16			
Cr	5100	519		411
Co	14.5	13.21		
Ni	170	144		383
Cu				
Zn				

Ga	3.3	
Ge		
As	<0.12	0.12
Se		
Rb		<4
Sr	127	171
Y		
Zr	<29	21
Nb		
Mo		
Ru		
Rh		
Pd ppb		
Ag ppb		
Cd ppb		
In ppb		
Sn ppb		
Sb ppb	<6	9
Te ppb		
Cs ppm	<0.052	<0.08
Ba	30	30
La	1.55	1.523
Ce	3.5	3.99
Pr		
Nd	2.45	2.5
Sm	0.77	0.788
Eu	0.79	0.75
Gd		
Tb	0.172	0.161
Dy	1.3	
Ho	0.21	
Er		
Tm		
Yb	0.67	0.634
Lu	0.097	0.0904
Hf	0.6	0.582
Ta	0.092	0.066
W ppb		<600
Re ppb		
Os ppb		
Ir ppb	5.9	5.3
Pt ppb		
Au ppb	2.8	3.4
Th ppm	0.23	0.24
U ppm	0.052	0.08

technique (a) ICP-AES, (b) ICP-MS, (c) IDMS, (d) Ar, (e) INAA, (f) RNAA, (g) EMPA

Table 1b. Light and/or volatile elements for NWA482

Li ppm
Be
C

S

F ppm

Cl

Br

2.1

I

Pb ppm

Hg ppb

Tl

Bi

1) Warren et al.(2005); 2) Korotev et al. (2003); 3) Dauber et al. (2002) shock melt glass